Product Manual

Constellation.2™ Serial ATA

Standard Models

ST91000640NS
ST9500620NS
ST9250610NS

Self-Encrypting Drive Models

ST91000641NS
ST9500621NS
ST9250611NS

SED FIPS 140-2 Models

ST91000642NS
ST9500622NS
ST9250612NS

100545983
Rev. C
February 2011

Revision history

Revision	Date	Sheets affected or comments
Rev. A	06/16/10	Initial release.
Rev. B	10/12/10	fc, 2, 15-19, 23-24 & 31.
Rev. C	02/14/11	5, 8, 10-12, 14 & 27.

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Publication number: 100545983, Rev. C February 2011

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One gigabyte, or GB, equals one billion bytes and one terabyte, or TB, equals one trillion bytes. Your computer's operating system may use a different standard of measurement and report a lower capacity. In addition, some of the listed capacity is used for formatting and other functions, and thus will not be available for data storage. Seagate reserves the right to change, without notice, product offerings or specifications.

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1.0 Seagate Technology support services

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For Seagate OEM & Distribution partner portal, visit https://direct.seagate.com/portal/system

For Seagate reseller portal, visit http://spp.seagate.com

2.0 Introduction

This manual describes the functional, mechanical and interface specifications for the following Seagate Constellation.2™ Serial ATA model drives:

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Model Number	Self-Encrypting Drive (SED)	FIPS 140-2 Level 2 certified
ST91000640NS	No	No
ST91000641NS	Yes	No
ST91000642NS	Yes	Yes
ST9500620NS	No	No
ST9500621NS	Yes	No
ST9500622NS	Yes	Yes
ST9250610NS	No	No
ST9250611NS	Yes	No
ST9250612NS	Yes	Yes

Note. Previous generations of Seagate Self-Encrypting Drive models were called Full Disk Encryption (FDE) models before a differentiation between drive-based encryption and other forms of encryption was necessary.

Note. The Self-Encrypting Drive models indicated on the cover of this product manual have provisions for "Security of Data at Rest" based on the standards defined by the Trusted Computing Group (see www.trustedcomputinggroup.org).

For more information on FIPS 140-2 Level 2 certification see See Section 5.0 on page 29.

These drives provide the following key features:

- 7200 RPM spindle speed.
- High instantaneous (burst) data-transfer rates (up to 600MB/s).
- Perpendicular recording technology provides the drives with increased areal density.
- State-of-the-art cache and on-the-fly error-correction algorithms.
- Native Command Queueing with command ordering to increase performance in demanding applications.
- Full-track multiple-sector transfer capability without local processor intervention.
- Quiet operation.
- SeaTools diagnostic software performs a drive self-test that eliminates unnecessary drive returns.
- Support for S.M.A.R.T. drive monitoring and reporting.
- Supports latching SATA cables and connectors.
- Worldwide Name (WWN) capability uniquely identifies the drive.

Constellation.2 Serial ATA Self-Encrypting Drive models have the following additional features:

- Automatic data encryption/decryption
- Controlled access
- Random number generator
- Drive locking
- 16 independent data bands
- Cryptographic erase of user data for a drive that will be repurposed or scrapped
- Authenticated firmware download

Note. There is no significant performance difference between Self-Encrypting Drive and standard (non-Self-Encrypting Drive) models.

2.1 About the Serial ATA interface

The Serial ATA interface provides several advantages over the traditional (parallel) ATA interface. The primary advantages include:

- Easy installation and configuration with true plug-and-play connectivity. It is not necessary to set any jumpers or other configuration options.
- Thinner and more flexible cabling for improved enclosure airflow and ease of installation.
- Scalability to higher performance levels.

In addition, Serial ATA makes the transition from parallel ATA easy by providing legacy software support. Serial ATA was designed to allow you to install a Serial ATA host adapter and Serial ATA disc drive in your current system and expect all of your existing applications to work as normal.

The Serial ATA interface connects each disc drive in a point-to-point configuration with the Serial ATA host adapter. There is no master/slave relationship with Serial ATA devices like there is with parallel ATA. If two drives are attached on one Serial ATA host adapter, the host operating system views the two devices as if they were both “masters” on two separate ports. This essentially means both drives behave as if they are Device 0 (master) devices.

Note. The host adapter may, optionally, emulate a master/slave environment to host software where two devices on separate Serial ATA ports are represented to host software as a Device 0 (master) and Device 1 (slave) accessed at the same set of host bus addresses. A host adapter that emulates a master/slave environment manages two sets of shadow registers. This is not a typical Serial ATA environment.

The Serial ATA host adapter and drive share the function of emulating parallel ATA device behavior to provide backward compatibility with existing host systems and software. The Command and Control Block registers, PIO and DMA data transfers, resets, and interrupts are all emulated.

The Serial ATA host adapter contains a set of registers that shadow the contents of the traditional device registers, referred to as the Shadow Register Block. All Serial ATA devices behave like Device 0 devices. For additional information about how Serial ATA emulates parallel ATA, refer to the “Serial ATA: High Speed Serialized AT Attachment” specification. The specification can be downloaded from www.serialata.org.

3.0 Drive specifications

Unless otherwise noted, all specifications are measured under ambient conditions, at 25°C, and nominal power. For convenience, the phrases *the drive* and *this drive* are used throughout this manual to indicate the following drive models:

Unless otherwise stated, the information in this manual applies to standard and Self-Encrypting Drive models

Model Number	Self-Encrypting Drive (SED)	FIPS 140-2 Level 2 certified
ST91000640NS	No	No
ST91000641NS	Yes	No
ST91000642NS	Yes	Yes
ST9500620NS	No	No
ST9500621NS	Yes	No
ST9500622NS	Yes	Yes
ST9250610NS	No	No
ST9250611NS	Yes	No
ST9250612NS	Yes	Yes

Product data communicated in this manual is specific only to the model numbers listed in this manual. The data listed in this manual may not be predictive of future generation specifications or requirements. If you are designing a system which will use one of the models listed or future generation products and need further assistance, please contact your Field Applications Engineer (FAE) or our global support services group as shown in Section 1.0.

3.1 Specification summary tables

The specifications listed in the following tables are for quick reference. For details on specification measurement or definition, see the appropriate section of this manual.

Table 1: Drive specifications summary for 1TB, 500 and 250 GB models

Drive specification	ST91000640NS ST91000641NS ST91000642NS	ST9500620NS ST9500621NS ST9500622NS	ST9250610NS ST9250611NS ST9250612NS
Formatted GB (512 bytes/sector)*	1000	500	250
Guaranteed sectors	1,953,525,168	976,773,168	488,397,168
Heads	8	4	2
Discs	4	2	1
Bytes per sector	512		
Default sectors per track	63		
Default read/write heads	16		
Default cylinders	16,383		
Recording density, KBPI (Kb/in max)	1544		
Track density, KTPI (Ktracks/in avg.)	270		
Areal density, (Gb/in^2 avg)	417		
Spindle speed (RPM)	7200		
Internal data transfer rate (Mb/s max)	1304		
Sustained data transfer rate OD (MB/s max)	115		
I/O data-transfer rate (MB/s max)	600		
ATA data-transfer modes supported	PIO modes 0–4 Multiword DMA modes 0–2 Ultra DMA modes 0–6		
Cache buffer	64 Mbytes		
Weight: (maximum)	200 g (0.441 lb)	183 g (0.403 lb)	179 g (0.395 lb)
Average latency	4.16 ms		
Power-on to ready (sec max)	20 sec		
Standby to ready (sec max)	13 sec		
Track-to-track seek time (ms typical)	0.23 read 0.44 write		
Average seek, read (ms typical)	7.5		
Average seek, write (ms typical)	8.5		
Startup current (typical) 12V (peak)	2.0 amps		
Voltage tolerance (including noise)	5V ±5% 12V ±5%		
Ambient temperature	5° to 60°C (operating) –40° to 70°C (nonoperating)		
Temperature gradient (°C per hour max)	20°C (operating) 20°C (nonoperating)		
Relative humidity	5% to 95% (operating) 5% to 95% (nonoperating)		
Relative humidity gradient	20% per hour max		
Wet bulb temperature (°C max)	28°C		
Altitude, operating	–60.96 m to 3,048 m (–200 ft. to 10,000+ ft.)		
Altitude, nonoperating (below mean sea level, max)	–60.96 m to 12,192 m (–200 ft. to 40,000+ ft.)		
Operational Shock (max at 2 ms)	Read 70 Gs / Write 40 Gs		
Non-Operational Shock (max at 2 ms)	400 Gs		
Vibration, operating	5–500 Hz: 0.5 Gs		
Vibration, nonoperating	5–500 Hz: 3.0 Gs		

Drive specification	ST91000640NS ST91000641NS ST91000642NS	ST9500620NS ST9500621NS ST9500622NS	ST9250610NS ST9250611NS ST9250612NS
Drive acoustics, sound power (bels)			
Active	2.8 (typical)		
Idle**	2.2 (typical)		
Nonrecoverable read errors	1 sector per 10^{15} bits read		
Annualized Failure Rate (AFR)	0.62%		
Warranty	To determine the warranty for a specific drive, use a web browser to access the following web page: http://www.seagate.com/www/en-us/support/warranty_&_returns_assistance From this page, click on the “Verify Your Warranty” link. You will be asked to provide the drive serial number, model number (or part number) and country of purchase. The system will display the warranty information for your drive.		
Load/Unload cycles	300,000 (25°C, 50% rel. humidity) (600,000 design life testing)		
Supports Hotplug operation per Serial ATA Revision 2.6 specification	Yes		

*One Gbyte equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary depending on operating environment and formatting.

**During periods of drive idle, some offline activity may occur according to the S.M.A.R.T. specification, which may increase acoustic and power to operational levels.

3.2 Formatted capacity

Model	Formatted capacity*	Guaranteed sectors	Bytes per sector
ST91000640NS ST91000641NS ST91000642NS	1000 GB	1,953,525,168	512
ST9500620NS ST9500621NS ST9500622NS	500 GB	976,773,168	
ST9250610NS ST9250611NS ST9250612NS	250 GB	488,397,168	

*One GB equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary depending on operating environment and formatting.

3.2.1 LBA mode

When addressing these drives in LBA mode, all blocks (sectors) are consecutively numbered from 0 to *n–1,* where *n* is the number of guaranteed sectors as defined above.

See Section 7.3.1, "Identify Device command" (words 60-61 and 100-103) for additional information about 48-bit addressing support of drives with capacities over 137 Gbytes.

3.3 Default logical geometry

Cylinders	Read/write heads	Sectors per track
16,383	16	63

LBA mode
When addressing these drives in LBA mode, all blocks (sectors) are consecutively numbered from 0 to *n–1,* where *n* is the number of guaranteed sectors as defined above.

3.4 Recording and interface technology

	All models
Interface	Serial ATA (SATA)
Recording method	Perpendicular
Recording density, KBPI (Kb/in max)	1544
Track density, KTPI (Ktracks/in avg)	270
Areal density (Gb/in^2 avg)	417
Spindle speed (RPM) (± 0.2%)	7200
Internal data transfer rate (Mb/s max)	1304
Sustained data transfer rate (MB/s max)	115
I/O data-transfer rate (MB/s max)	600

3.5 Physical characteristics

Weight: (**maximum)**	
1TB models	200 g (0.441 lb)
500GB models	183 g (0.403 lb)
250GB models	179 g (0.395 lb)
Cache buffer	64 Mbytes (65,536 KB)

Note. Refer to Figure 6, page 27 for detailed mounting configuration dimensions.

3.6 Seek time

Seek measurements are taken with nominal power at 25°C ambient temperature. All times are measured using drive diagnostics. The specifications in the table below are defined as follows:

- Track-to-track seek time is an average of all possible single-track seeks in both directions.
- Average seek time is a true statistical random average of at least 5,000 measurements of seeks between random tracks, less overhead.

***Typical seek times (ms)**	**Read**	**Write**
Track-to-track	0.23	0.44
Average	7.5	8.5
Full Stroke	17.06	18.08
Average latency:	4.16	

*Measured in performance mode.

Note. These drives are designed to consistently meet the seek times represented in this manual. Physical seeks, regardless of mode (such as track-to-track and average), are expected to meet the noted values. However, due to the manner in which these drives are formatted, benchmark tests that include command overhead or measure logical seeks may produce results that vary from these specifications.

3.7 Start/stop times

Power-on to Ready (sec)	20 (max)
Standby to Ready (sec)	13 (max)
Ready to spindle stop (sec)	20 (max)

3.8 Power specifications

The drive receives DC power (+5V or +12V) through a native SATA power connector. See Figure 5, page 26 on page 26.

3.8.1 Power consumption

Power requirements for the drives are listed in the table on page 9. Typical power measurements are based on an average of drives tested, under nominal conditions, using 5.0V and 12.0V input voltage at 25°C ambient temperature.

- **Spinup power**

  Spinup power is measured from the time of power-on to the time that the drive spindle reaches operating speed.

- **Standby mode**

  During Standby mode, the drive accepts commands, but the drive is not spinning, and the servo and read/write electronics are in power-down mode.

The standard drive models and the SED drive models have identical hardware, however the security and encryption portion of the drive controller ASIC is enabled and functional in the SED models. This represents a small additional drain on the 5V supply of about 30mA and a commensurate increase of about 150mW in power consumption. There is no additional drain on the 12V supply.

Table 2: 1000GB drive (Standard & SED model) DC power requirementss

Parameter	ST91000640NS (3.0GB)			ST91000640NS (6.0GB)		
Voltage	**+5 V**	**+12 V**	**Power**	**+5 V**	**+12 V**	**Power**
Regulation	**+/-5%**		**(watts)**	**+/-5%**		**(watts)**
Average Idle Current	0.22	0.15	2.92	0.23	0.15	2.95
Advanced Idle Current						
Idle1	0.22	0.15	2.91	0.23	0.15	2.96
Idle2	0.15	0.13	2.28	0.16	0.13	2.32
Idle3	0.15	0.09	1.84	0.16	0.09	1.89
Standby	0.14	0.04	1.20	0.14	0.04	1.23
Average Sleep Current	0.14	0.04	1.17	0.14	0.04	1.21
Maximum Start Current:						
DC (Peak DC)	0.51	0.85	12.70	0.51	0.85	12.73
AC (Peak AC)	0.70	1.20	17.93	0.74	1.22	18.35
Delayed Motor Start (DC max)	0.14	0.04	1.20	0.14	0.04	1.22
Peak Operating Current (random read):						
Typical DC	0.30	0.32	5.39	0.31	0.32	5.43
Maximum DC	0.30	0.33	5.45	0.32	0.33	5.52
Maximum DC (peak)	1.04	0.88	15.76	1.02	0.90	15.90
Peak Operating Current (random write):						
Typical DC	0.38	0.27	5.20	0.39	0.27	5.25
Maximum DC	0.39	0.27	5.23	0.40	0.28	5.32
Maximum DC (peak)	0.94	0.88	15.26	0.96	0.90	15.60
Peak operating current (sequential read):						
Typical DC	0.61	0.18	5.17	0.62	0.18	5.21
Maximum DC	0.62	0.18	5.24	0.64	0.18	5.31
Maximum DC (peak)	0.82	0.34	8.18	0.86	0.34	8.38
Peak operating current (sequential write):						
Typical DC	0.77	0.18	5.96	0.78	0.18	6.00
Maximum DC	0.78	0.18	6.04	0.81	0.18	6.16
Maximum DC (peak)	0.98	0.34	8.98	0.98	0.38	9.46

*During periods of drive idle, some offline activity may occur according to the S.M.A.R.T. specification, which may increase acoustic and power to operational levels.

500GB drive (Standard & SED model) DC power requirements

Parameter	ST9500620NS (3.0GB)			ST9500620NS (6.0GB)		
Voltage	**+5 V**	**+12 V**	**Power**	**+5 V**	**+12 V**	**Power**
Regulation	**+/-5%**		**(watts)**	**+/-5%**		**(watts)**
Average Idle Current	0.22	0.11	2.40	0.23	0.11	2.44
Advanced Idle Current						
Idle1	0.22	0.11	2.40	0.23	0.11	2.43
Idle2	0.16	0.09	1.88	0.16	0.09	1.93
Idle3	0.16	0.07	1.64	0.16	0.07	1.67
Standby	0.14	0.04	1.17	0.15	0.04	1.22
Average Sleep Current	0.14	0.04	1.17	0.15	0.04	1.20
Maximum Start Current:						
DC (Peak DC)	0.47	0.80	11.93	0.47	0.80	11.98
AC (Peak AC)	0.69	1.18	17.66	0.63	1.19	17.38
Delayed Motor Start (DC max)	0.14	0.04	1.19	0.15	0.04	1.23
Peak Operating Current (random read):						
Typical DC	0.29	0.27	4.69	0.29	0.27	4.73
Maximum DC	0.29	0.27	4.74	0.30	0.28	4.79
Maximum DC (peak)	0.96	0.82	14.64	1.00	0.86	15.32
Peak Operating Current (random write):						
Typical DC	0.37	0.23	4.55	0.37	0.23	4.59
Maximum DC	0.37	0.23	4.61	0.38	0.23	4.65
Maximum DC (peak)	0.90	0.86	14.82	0.92	0.84	14.68
Peak operating current (sequential read):						
Typical DC	0.58	0.13	4.46	0.59	0.13	4.49
Maximum DC	0.59	0.13	4.54	0.60	0.13	4.55
Maximum DC (peak)	0.76	0.30	7.40	0.80	0.30	7.60
Peak operating current (sequential write):						
Typical DC	0.75	0.13	5.28	0.75	0.13	5.31
Maximum DC	0.77	0.13	5.40	0.77	0.13	5.40
Maximum DC (peak)	0.92	0.30	8.20	0.98	0.28	8.26

*During periods of drive idle, some offline activity may occur according to the S.M.A.R.T. specification, which may increase acoustic and power to operational levels.

250GB drive (Standard & SED model) DC power requirements

Parameter	ST9250610NS (3.0GB)			ST9250610NS (6.0GB)		
Voltage	**+5 V**	**+12 V**	**Power**	**+5 V**	**+12 V**	**Power**
Regulation	**+/-5%**		**(watts)**	**+/-5%**		**(watts)**
Average Idle Current	0.22	0.09	2.23	0.23	0.09	2.25
Advanced Idle Current						
Idle1	0.22	0.09	2.22	0.22	0.09	2.24
Idle2	0.16	0.08	1.81	0.17	0.08	1.82
Idle3	0.16	0.07	1.61	0.16	0.07	1.63
Standby	0.14	0.04	1.20	0.15	0.04	1.24
Average Sleep Current	0.14	0.04	1.20	0.15	0.04	1.22
Maximum Start Current:						
DC (Peak DC)	0.51	0.78	11.96	0.52	0.78	11.92
AC (Peak AC)	0.64	1.14	16.93	0.60	1.14	16.70
Delayed Motor Start (DC max)	0.15	0.04	1.24	0.16	0.04	1.29
Peak Operating Current (random read):						
Typical DC	0.29	0.26	4.54	0.30	0.26	4.61
Maximum DC	0.29	0.26	4.63	0.30	0.27	4.71
Maximum DC (peak)	0.96	0.84	14.88	0.96	0.82	14.64
Peak Operating Current (random write):						
Typical DC	0.39	0.21	4.48	0.39	0.22	4.55
Maximum DC	0.39	0.22	4.55	0.40	0.22	4.64
Maximum DC (peak)	0.82	0.84	14.18	0.84	0.80	13.80
Peak operating current (sequential read):						
Typical DC	0.57	0.11	4.17	0.58	0.11	4.22
Maximum DC	0.58	0.11	4.25	0.59	0.11	4.32
Maximum DC (peak)	0.74	0.28	7.06	0.78	0.26	7.02
Peak operating current (sequential write):						
Typical DC	0.70	0.11	4.81	0.70	0.11	4.86
Maximum DC	0.71	0.11	4.89	0.72	0.11	4.95
Maximum DC (peak)	0.86	0.26	7.42	0.90	0.26	7.62

*During periods of drive idle, some offline activity may occur according to the S.M.A.R.T. specification, which may increase acoustic and power to operational levels.

3.8.1.1 Typical current profiles

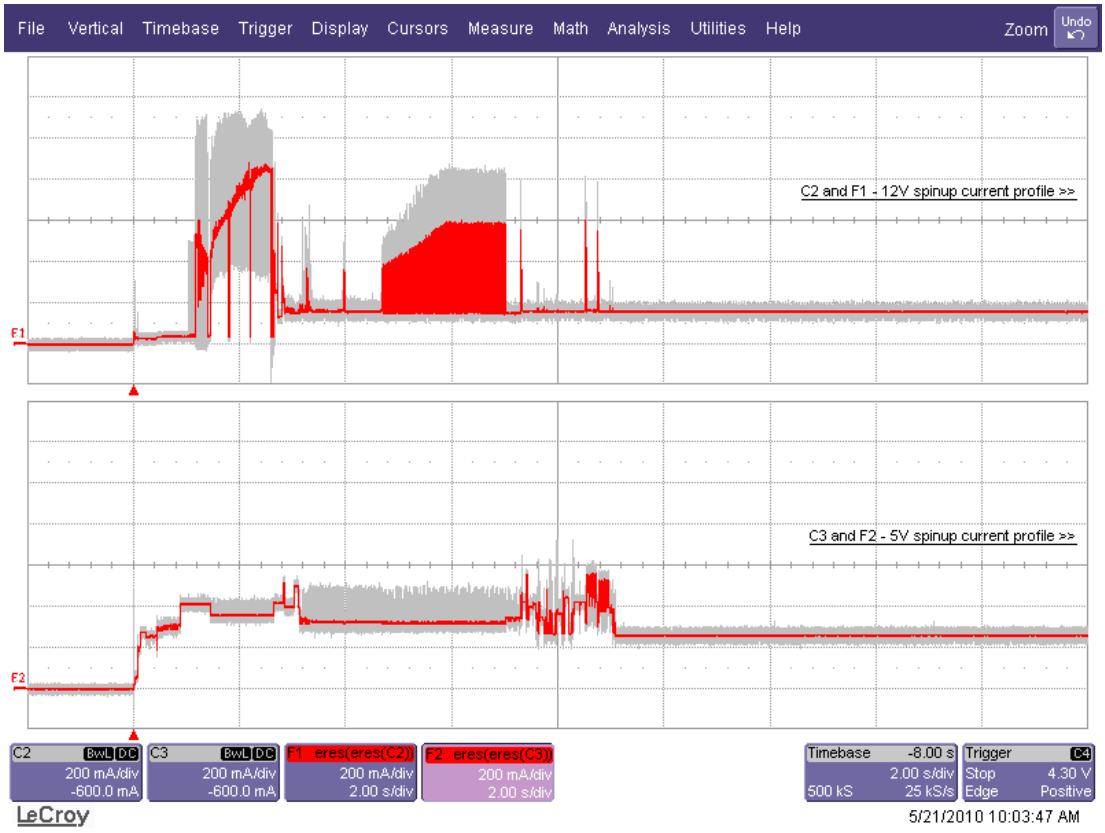

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help Zoom Undo
C2 and F1 - 12V spinup current profile >>
F1
C3 and F2 - 5V spinup current profile >>
F2
C2 BwL DC 200 mA/div -600.0 mA
C3 BwL DC 200 mA/div -600.0 mA
F1 eres(eres(C2)) 200 mA/div 2.00 s/div
F2 eres(eres(C3)) 200 mA/div 2.00 s/div
Timebase -8.00 s 2.00 s/div 500 kS 25 kS/s
Trigger C4 Stop 4.30 V Edge Positive
LeCroy
5/21/2010 10:03:47 AM

Figure 1. Typical 5V/12V startup and operation current profile for 1TB models

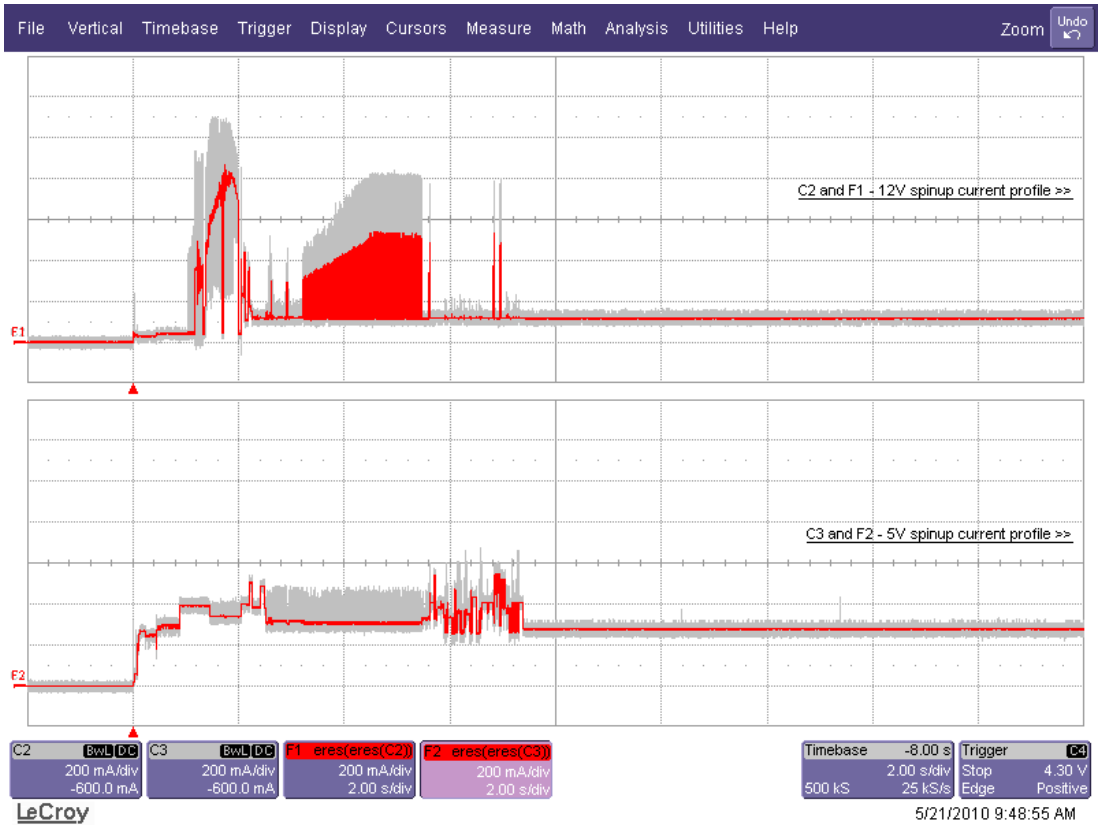

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help Zoom Undo
C2 and F1 - 12V spinup current profile >>
F1
C3 and F2 - 5V spinup current profile >>
F2
C2 BwL DC 200 mA/div -600.0 mA
C3 BwL DC 200 mA/div -600.0 mA
F1 eres(eres(C2)) 200 mA/div 2.00 s/div
F2 eres(eres(C3)) 200 mA/div 2.00 s/div
Timebase -8.00 s 2.00 s/div 500 kS 25 kS/s
Trigger C4 Stop 4.30 V Edge Positive
LeCroy
5/21/2010 9:48:55 AM

Figure 2. Typical 5V/12V startup and operation current profile for 500GB models

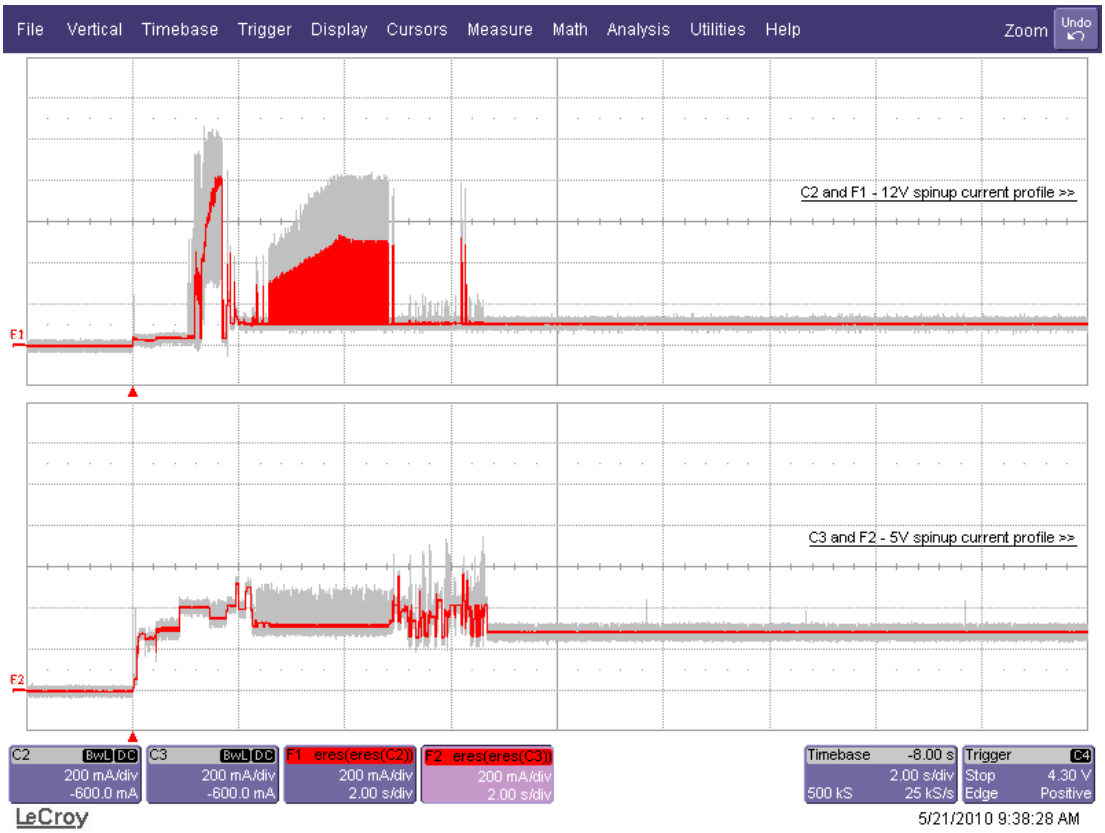

File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help Zoom Undo
C2 and F1 - 12V spinup current profile >>
F1
C3 and F2 - 5V spinup current profile >>
F2
C2 BwL DC 200 mA/div -600.0 mA
C3 BwL DC 200 mA/div -600.0 mA
F1 eres(eres(C2)) 200 mA/div 2.00 s/div
F2 eres(eres(C3)) 200 mA/div 2.00 s/div
Timebase -8.00 s 2.00 s/div 500 kS 25 kS/s
Trigger C4 Stop 4.30 V Edge Positive
LeCroy
5/21/2010 9:38:28 AM

Figure 3. Typical 5V/12V startup and operation current profile for 250GB models

3.8.2 Conducted noise

Noise is specified as a periodic and random distribution of frequencies covering a band from DC to 10 MHz. Maximum allowed noise values given below are peak-to-peak measurements and apply at the drive power connector.

- +5v = 250 mV pp from 100 Hz to 20 MHz.
- +12v = 450 mV pp from 8 kHz to 20 kHz.
  = 250 mV pp from 20 kHz to 5 MHz.

Note. Equivalent resistance is calculated by dividing the nominal voltage by the typical RMS read/write current.

3.8.3 Voltage tolerance

Voltage tolerance (including noise):

5V ± 5%
12V ± 5%

3.8.4 Power-management modes

The drive provides programmable power management to provide greater energy efficiency. In most systems, you can control power management through the system setup program. The drive features the following power-management modes:

Power modes	Heads	Spindle	Buffer
Active	Tracking	Rotating	Enabled
Idle_a	ID Biased	Rotating	Enabled
Idle_b	Parked	Rotating	Enabled
Idle_c	Parked	Rotating at lower RPM	Enabled
Standby	Parked	Stopped	Enabled
Sleep	Parked	Stopped	Disabled

- **Active mode**
  The drive is in Active mode during the read/write and seek operations.
- **Idle mode**
  The buffer remains enabled, and the drive accepts all commands and returns to Active mode any time disc access is necessary.
- **Standby mode**
  The drive enters Standby mode when the host sends a Standby Immediate command. If the host has set the standby timer, the drive can also enter Standby mode automatically after the drive has been inactive for a specifiable length of time. The standby timer delay is established using a Standby or Idle command. In Standby mode, the drive buffer is enabled, the heads are parked and the spindle is at rest. The drive accepts all commands and returns to Active mode any time disc access is necessary.
- **Sleep mode**
  The drive enters Sleep mode after receiving a Sleep command from the host. In Sleep mode, the drive buffer is disabled, the heads are parked and the spindle is at rest. The drive leaves Sleep mode after it receives a Hard Reset or Soft Reset from the host. After receiving a reset, the drive exits Sleep mode and enters Standby mode with all current translation parameters intact.
- **Idle and Standby timers**
  Each time the drive performs an Active function (read, write or seek), the standby timer is reinitialized and begins counting down from its specified delay times to zero. If the standby timer reaches zero before any drive activity is required, the drive makes a transition to Standby mode. In both Idle and Standby mode, the drive accepts all commands and returns to Active mode when disc access is necessary.

3.8.4.1 Extended Power Conditions - PowerChoice™

Utilizing the load/unload architecture a programmable power management interface is provided to tailor systems for reduced power consumption and performance requirements.

The table below lists the supported power conditions available in PowerChoice. Power conditions are ordered from highest power consumption (and shortest recovery time) to lowest power consumption (and longest recovery time) as follows: Idle_a power >= Idle_b power >= Idle_c power >= Standby_z power. The further you go down in the table, the more power savings is actualized. For example, Idle_b results in greater power savings than the Idle_a power condition. Standby results in the greatest power savings.

Power Condition Name	Power Condition ID	Description
Idle_a	81_H	Reduced electronics
Idle_b	82_H	Heads unloaded. Disks spinning at full RPM
Idle_c	83_H	Heads unloaded. Disks spinning at reduced RPM
Standby_z	00_H	Heads unloaded. Motor stopped (disks not spinning)

Each power condition has a set of current, saved and default settings. Default settings are not modifiable. Default and saved settings persist across power-on resets. The current settings do not persist across power-on resets. At the time of manufacture, the default, saved and current settings are in the Power Conditions log match.

PowerChoice is invoked using one of two methods

- Automatic power transitions which are triggered by expiration of individual power condition timers. These timer values may be customized and enabled using the Extended Power Conditions (EPC) feature set using the standardized Set Features command interface.
- Immediate host commanded power transitions may be initiated using an EPC Set Features "Go to Power Condition" subcommand to enter any supported power condition. Legacy power commands Standby Immediate and Idle Immediate also provide a method to directly transition the drive into supported power conditions.

PowerChoice exits power saving states under the following conditions

- Any command which requires the drive to enter the PM0: Active state (media access)
- Power on reset

PowerChoice provides the following reporting methods for tracking purposes

Check Power Mode Command

- Reports the current power state of the drive

Identify Device Command

- EPC Feature set supported flag
- EPC Feature enabled flag is set if at least one Idle power condition timer is enabled

Power Condition Log reports the following for each power condition

- Nominal recovery time from the power condition to active
- If the power condition is Supported, Changeable, and Savable
- Default enabled state, and timer value
- Saved enabled state, and timer value
- Current enabled state, and timer value

S.M.A.R.T. Read Data Reports

- Attribute 192 - Emergency Retract Count
- Attribute 193 - Load/Unload Cycle Count

3.9 Environmental limits

Temperature and humidity values experienced by the drive must be such that condensation does not occur on any drive part. Altitude and atmospheric pressure specifications are referenced to a standard day at 58.7°F (14.8°C). Maximum wet bulb temperature is 82°F (28°C).

3.9.1 Temperature

a. Operating

The drive meets the operating specifications over a 41°F to 140°F (5°C to 60°C) drive case temperature range with a maximum temperature gradient of 36°F (20°C) per hour.

The maximum allowable drive case temperature is 60°C.

The MTBF specification for the drive assumes the operating environment is designed to maintain nominal case temperature. The rated MTBF is based upon a sustained case temperature of 104°F (40°C). Occasional excursions in operating temperature between the rated MTBF temperature and the maximum drive operating case temperature may occur without impact to the rated MTBF temperature. However continual or sustained operation at case temperatures beyond the rated MTBF temperature will degrade the drive MTBF and reduce product reliability.

Air flow may be required to achieve consistent nominal case temperature values (see Section 4.5). To confirm that the required cooling is provided for the electronics and HDA, place the drive in its final mechanical configuration, and perform random write/read operations. After the temperatures stabilize, measure the case temperature of the drive.

b. Non-operating

–40° to 158°F (–40° to 70°C) package ambient with a maximum gradient of 36°F (20°C) per hour. This specification assumes that the drive is packaged in the shipping container designed by Seagate for use with drive.

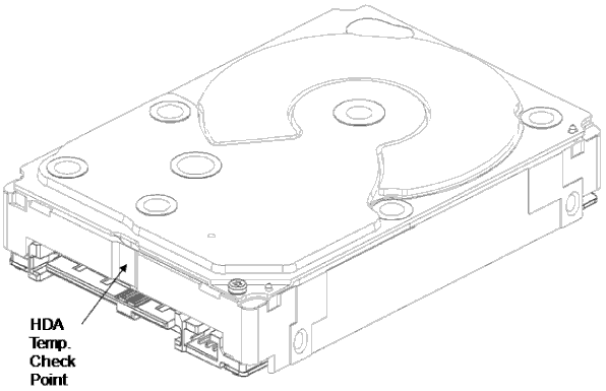


Figure 4. Location of the HDA temperature check point

3.9.2 Relative humidity

The values below assume that no condensation on the drive occurs.

a.Operating

5% to 95% non-condensing relative humidity with a maximum gradient of 20% per hour.

b.Non-operating

5% to 95% non-condensing relative humidity.

3.9.3 Effective altitude (sea level)

a. Operating

-200 to +10,000 feet (-61 to +3,048 meters)

b. Non-operating

-200 to +40,000 feet (-61 to +12,210 meters)

3.9.4 Shock

All shock specifications assume that the drive is mounted securely with the input shock applied at the drive mounting screws. Shock may be applied in the X, Y or Z axis.

3.9.4.1 Operating shock

These drives comply with the performance levels specified in this document when subjected to a maximum operating shock of Read 70 Gs and Write 40 Gs based on half-sine shock pulses of 2ms. Shocks should not be repeated more than once every 2 seconds.

3.9.4.2 Nonoperating shock

The nonoperating shock level that the drive can experience without incurring physical damage or degradation in performance when subsequently put into operation is 400 Gs based on a nonrepetitive half-sine shock pulse of 2ms duration.

3.9.5 Vibration

All vibration specifications assume that the drive is mounted securely with the input vibration applied at the drive mounting screws. Vibration may be applied in the X, Y or Z axis.

3.9.5.1 Operating vibration

The maximum vibration levels that the drive may experience while meeting the performance standards specified in this document are specified below.

5–500 Hz	0.50 Gs

3.9.5.2 Nonoperating vibration

The maximum nonoperating vibration levels that the drive may experience without incurring physical damage or degradation in performance when subsequently put into operation are specified below.

5–500 Hz	3.0 Gs

3.10 Acoustics

Drive acoustics are measured as overall A-weighted acoustic sound power levels (no pure tones). All measurements are consistent with ISO document 7779. Sound power measurements are taken under essentially free-field conditions over a reflecting plane. For all tests, the drive is oriented with the cover facing upward.

Note. For seek mode tests, the drive is placed in seek mode only. The number of seeks per second is defined by the following equation:

(Number of seeks per second = 0.4 / (average latency + average access time)

Table 3: Fluid Dynamic Bearing (FDB) motor acoustics

Active	Idle*
2.8 bels (typ)	2.2 bels (typ)

*During periods of drive idle, some offline activity may occur according to the S.M.A.R.T. specification, which may increase acoustic and power to operational levels.

3.11 Electromagnetic immunity

When properly installed in a representative host system, the drive operates without errors or degradation in performance when subjected to the radio frequency (RF) environments defined in the following table:

Table 4: Radio frequency environments

Test	Description	Performance level	Reference standard
Electrostatic discharge	Contact, HCP, VCP: ± 4 kV; Air: ± 8 kV	B	EN 61000-4-2: 95
Radiated RF immunity	80 to 1,000 MHz, 3 V/m, 80% AM with 1 kHz sine 900 MHz, 3 V/m, 50% pulse modulation @ 200 Hz	A	EN 61000-4-3: 96 ENV 50204: 95
Electrical fast transient	± 1 kV on AC mains, ± 0.5 kV on external I/O	B	EN 61000-4-4: 95
Surge immunity	± 1 kV differential, ± 2 kV common, AC mains	B	EN 61000-4-5: 95
Conducted RF immunity	150 kHz to 80 MHz, 3 Vrms, 80% AM with 1 kHz sine	A	EN 61000-4-6: 97
Voltage dips, interrupts	0% open, 5 seconds 0% short, 5 seconds 40%, 0.10 seconds 70%, 0.01 seconds	C C C B	EN 61000-4-11: 94

3.12 Reliability

3.12.1 Annualized Failure Rate (AFR) and Mean Time Between Failures (MTBF)

The product shall achieve an Annualized Failure Rate - AFR - of 0.62% (Mean Time Between Failures - MTBF - of 1.4 Million hrs) when operated in an environment that ensures the HDA case temperatures do not exceed 40°C. Operation at case temperatures outside the specifications in Section 3.9 may increase the product Annualized Failure Rate (decrease MTBF). AFR and MTBF are population statistics that are not relevant to individual units.

AFR and MTBF specifications are based on the following assumptions for business critical storage system environments:

- 8760 power-on-hours per year.
- 250 average motor start/stop cycles per year.
- Operations at nominal voltages.
- Systems will provide adequate cooling to ensure the case temperatures do not exceed 40°C. Temperatures outside the specifications in Section 3.8 will increase the product AFR and decrease MTBF.

Nonrecoverable read errors	1 per 10^{15} bits read, max
Annualized Failure Rate (AFR)	0.62% (nominal power, 40°C case temperature)
Load unload cycles	300,000 cycles
Warranty	To determine the warranty for a specific drive, use a web browser to access the following web page: http://www.seagate.com/www/en-us/support/warranty_&_returns_assistance From this page, click on the “Verify Your Warranty” link. You will be asked to provide the drive serial number, model number (or part number) and country of purchase. The system will display the warranty information for your drive.
Preventive maintenance	None required.

3.13 Agency certification

3.13.1 Safety certification

The drives are recognized in accordance with UL 60950-1 as tested by UL, CSA 60950-1 as tested by CSA, and EN60950-1 as tested by TUV.

The security features of Self-Encrypting Drive models are based on the “TCG Storage Architecture Core Specification” and the “TCG Storage Workgroup Security Subsystem Class: Enterprise_A” specification with additional vendor-unique features as noted in this product manual.

3.13.2 Electromagnetic compatibility

Hard drives that display the CE mark comply with the European Union (EU) requirements specified in the Electromagnetic Compatibility Directive (2004/108/EC) as put into place 20 July 2007. Testing is performed to the levels specified by the product standards for Information Technology Equipment (ITE). Emission levels are defined by EN 55022, Class B and the immunity levels are defined by EN 55024.

Seagate uses an independent laboratory to confirm compliance with the EC directives specified in the previous paragraph. Drives are tested in representative end-user systems. Although CE-marked Seagate drives comply with the directives when used in the test systems, we cannot guarantee that all systems will comply with the directives. The drive is designed for operation inside a properly designed enclosure, with properly shielded I/O cable (if necessary) and terminators on all unused I/O ports. Computer manufacturers and system integrators should confirm EMC compliance and provide CE marking for their products.

Korean RRL

If these drives have the Korean Communications Commission (KCC) logo, they comply with paragraph 1 of Article 11 of the Electromagnetic Compatibility control Regulation and meet the Electromagnetic Compatibility (EMC) Framework requirements of the Radio Research Laboratory (RRL) Communications Commission, Republic of Korea.

These drives have been tested and comply with the Electromagnetic Interference/Electromagnetic Susceptibility (EMI/EMS) for Class B products. Drives are tested in a representative, end-user system by a Korean-recognized lab.

- Family name: Constellation.2 Serial ATA
- Certificate number: STX- ST91000640NS (B)

Australian C-Tick (N176)

If these models have the C-Tick marking, they comply with the Australia/New Zealand Standard AS/NZ CISPR22 and meet the Electromagnetic Compatibility (EMC) Framework requirements of the Australian Communication Authority (ACA).

3.13.3 FCC verification

These drives are intended to be contained solely within a personal computer or similar enclosure (not attached as an external device). As such, each drive is considered to be a subassembly even when it is individually marketed to the customer. As a subassembly, no Federal Communications Commission verification or certification of the device is required.

Seagate Technology LLC has tested this device in enclosures as described above to ensure that the total assembly (enclosure, disc drive, motherboard, power supply, etc.) does comply with the limits for a Class B computing device, pursuant to Subpart J, Part 15 of the FCC rules. Operation with noncertified assemblies is likely to result in interference to radio and television reception.

Radio and television interference. This equipment generates and uses radio frequency energy and if not installed and used in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception.

This equipment is designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television, which can be determined by turning the equipment on and off, you are encouraged to try one or more of the following corrective measures:

- Reorient the receiving antenna.
- Move the device to one side or the other of the radio or TV.
- Move the device farther away from the radio or TV.
- Plug the computer into a different outlet so that the receiver and computer are on different branch outlets.

If necessary, you should consult your dealer or an experienced radio/television technician for additional suggestions. You may find helpful the following booklet prepared by the Federal Communications Commission: *How to Identify and Resolve Radio-Television Interference Problems*. This booklet is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Refer to publication number 004-000-00345-4.

3.14 Environmental protection

Seagate designs its products to meet environmental protection requirements worldwide, including regulations restricting certain chemical substances.

3.14.1 European Union Restriction of Hazardous Substances (RoHS) Directive

The European Union Restriction of Hazardous Substances (RoHS) Directive, restricts the presence of chemical substances, including Lead, Cadmium, Mercury, Hexavalent Chromium, PBB and PBDE, in electronic products, effective July 2006. This drive is manufactured with components and materials that comply with the RoHS Directive.

3.14.2 Reference documents

Self-Encrypting Drives Reference Manual
Seagate part number: 100515636

Trusted Computing Group (TCG) Documents (apply to Self-Encrypting Drive models only)
TCG Storage Architecture Core Specification, Rev. 1.0
TCG Storage Security Subsystem Class Enterprise Specification, Rev. 1.0

In case of conflict between this document and any referenced document, this document takes precedence.

3.14.3 Product warranty

Beginning on the date of shipment to the customer and continuing for the period specified in your purchase contract, Seagate warrants that each product (including components and subassemblies) that fails to function properly under normal use due to defect in materials or workmanship or due to nonconformance to the applicable specifications will be repaired or replaced, at Seagate's option and at no charge to the customer, if returned by customer at customer's expense to Seagate's designated facility in accordance with Seagate's warranty procedure. Seagate will pay for transporting the repair or replacement item to the customer. For more detailed warranty information, refer to the standard terms and conditions of purchase for Seagate products on your purchase documentation.

The remaining warranty for a particular drive can be determined by calling Seagate Customer Service at 1-800-468-3472. You can also determine remaining warranty using the Seagate web site (www.seagate.com). The drive serial number is required to determine remaining warranty information.

Shipping

When transporting or shipping a drive, use only a Seagate-approved container. Keep your original box. Seagate approved containers are easily identified by the Seagate Approved Package label. Shipping a drive in a non-approved container voids the drive warranty.

Seagate repair centers may refuse receipt of components improperly packaged or obviously damaged in transit. Contact your authorized Seagate distributor to purchase additional boxes. Seagate recommends shipping by an air-ride carrier experienced in handling computer equipment.

Storage

The maximum recommended storage period for the drive in a non-operational environment is 90 days. Drives should be stored in the original unopened Seagate shipping packaging whenever possible. Once the drive is removed from the Seagate original packaging the recommended maximum period between drive operation cycles is 30 days. During any storage period the drive non-operational temperature, humidity, wet bulb, atmospheric conditions, shock, vibration, magnetic and electrical field specifications should be followed.

Product repair and return information

Seagate customer service centers are the only facilities authorized to service Seagate drives. Seagate does not sanction any third-party repair facilities. Any unauthorized repair or tampering with the factory seal voids the warranty.

3.14.4 China Restriction of Hazardous Substances (RoHS) Directive 中国限制危险物品的指令

This product has an Environmental Protection Use Period (EPUP) of 20 years. The following table contains information mandated by China's "Marking Requirements for Control of Pollution Caused by Electronic Information Products" Standard.

该产品具有20年的环境保护使用周期 （EPUP）。 下表包含了中国 “电子产品所导致的污染的控制的记号要求”所指定的信息。

Name of Parts 部件名称	Toxic or Hazardous Substances or Elements有毒有害物质或元素					
	Lead 铅 （Pb）	Mercury 汞 （Hg）	Cadmium 镉 （Cd）	Hexavalent Chromium 六价铬 （Cr6+）	Polybrominated Biphenyl 多溴联苯 （PBB）	Polybrominated Diphenyl Ether 多溴二苯醚 （PBDE）
PCBA	X	O	O	O	O	O
HDA	X	O	O	O	O	O

"O" indicates the hazardous and toxic substance content of the part (at the homogenous material level) is lower than the threshold defined by the China RoHS MCV Standard.

O"表示该部件（于同类物品程度上）所含的危险和有毒物质低于中国RoHS MCV标准所定义的门槛值。

"X" indicates the hazardous and toxic substance content of the part (at the homogenous material level) is over the threshold defined by the China RoHS MCV Standard.

X "表示该部件（于同类物品程度上）所含的危险和有毒物质超出中国RoHS MCV标准所定义的门槛值。

3.15 Corrosive environment

Seagate electronic drive components pass accelerated corrosion testing equivalent to 10 years exposure to light industrial environments containing sulfurous gases, chlorine and nitric oxide, classes G and H per ASTM B845. However, this accelerated testing cannot duplicate every potential application environment. Users should use caution exposing any electronic components to uncontrolled chemical pollutants and corrosive chemicals as electronic drive component reliability can be affected by the installation environment. The silver, copper, nickel and gold films used in Seagate products are especially sensitive to the presence of sulfide, chloride, and nitrate contaminants. Sulfur is found to be the most damaging. In addition, electronic components should never be exposed to condensing water on the surface of the printed circuit board assembly (PCBA) or exposed to an ambient relative humidity greater than 95%. Materials used in cabinet fabrication, such as vulcanized rubber, that can outgas corrosive compounds should be minimized or eliminated. The useful life of any electronic equipment may be extended by replacing materials near circuitry with sulfide-free alternatives.

4.0 Configuring and mounting the drive

This section contains the specifications and instructions for configuring and mounting the drive.

4.1 Handling and static-discharge precautions

After unpacking, and before installation, the drive may be exposed to potential handling and electrostatic discharge (ESD) hazards. Observe the following standard handling and static-discharge precautions:

Caution:

- Before handling the drive, put on a grounded wrist strap, or ground yourself frequently by touching the metal chassis of a computer that is plugged into a grounded outlet. Wear a grounded wrist strap throughout the entire installation procedure.
- Handle the drive by its edges or frame *only*.
- The drive is extremely fragile—handle it with care. Do not press down on the drive top cover.
- Always rest the drive on a padded, antistatic surface until you mount it in the computer.
- Do not touch the connector pins or the printed circuit board.
- Do not remove the factory-installed labels from the drive or cover them with additional labels. Removal voids the warranty. Some factory-installed labels contain information needed to service the drive. Other labels are used to seal out dirt and contamination.

4.2 Configuring the drive

Each drive on the Serial ATA interface connects point-to-point with the Serial ATA host adapter. There is no master/slave relationship because each drive is considered a master in a point-to-point relationship. If two drives are attached on one Serial ATA host adapter, the host operating system views the two devices as if they were both “masters” on two separate ports. Both drives behave as if they are Device 0 (master) devices.

Serial ATA drives are designed for easy installation. It is usually not necessary to set any jumpers on the drive for proper operation; however, if you connect the drive and receive a “drive not detected” error, your SATA-equipped motherboard or host adapter may use a chipset that does not support SATA speed autonegotiation.

4.3 Serial ATA cables and connectors

The Serial ATA interface cable consists of four conductors in two differential pairs, plus three ground connections. The cable size may be 30 to 26 AWG with a maximum length of one meter (39.37in). See Table 5 for connector pin definitions. Either end of the SATA signal cable can be attached to the drive or host.

For direct backplane connection, the drive connectors are inserted directly into the host receptacle. The drive and the host receptacle incorporate features that enable the direct connection to be hot pluggable and blind mateable.

For installations which require cables, you can connect the drive as illustrated in Figure 5, page 26.

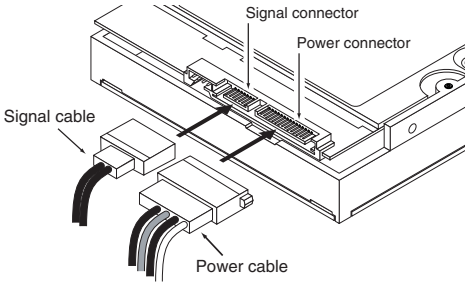


Figure 5. Attaching SATA cabling

Each cable is keyed to ensure correct orientation. Constellation.2 Serial ATA drives support latching SATA connectors.

4.4 Drive mounting

You can mount the drive in any orientation using four screws in the side-mounting holes or four screws in the bottom-mounting holes. See Figure 6, page 27 for drive mounting dimensions. Follow these important mounting precautions when mounting the drive:

- Allow a minimum clearance of 0.030 in (0.76 mm) around the entire perimeter of the drive for cooling as a guideline. Please refer to Section 4.5 for final cooling requirements.
- Use only M3 x 0.5 metric mounting screws.
- Four (4) threads (0.080 in) minimum screw engagement recommended. Also ensure maximum screw length does not bottom out in mounting holes.
- Do not overtighten the mounting screws (maximum torque: 4.5 in-lb, ± 0.45 in-lb)

Note. These dimensions conform to the Small Form Factor Standard documented in SFF-8201 and SFF-8223 found at www.sffcommittee.org.

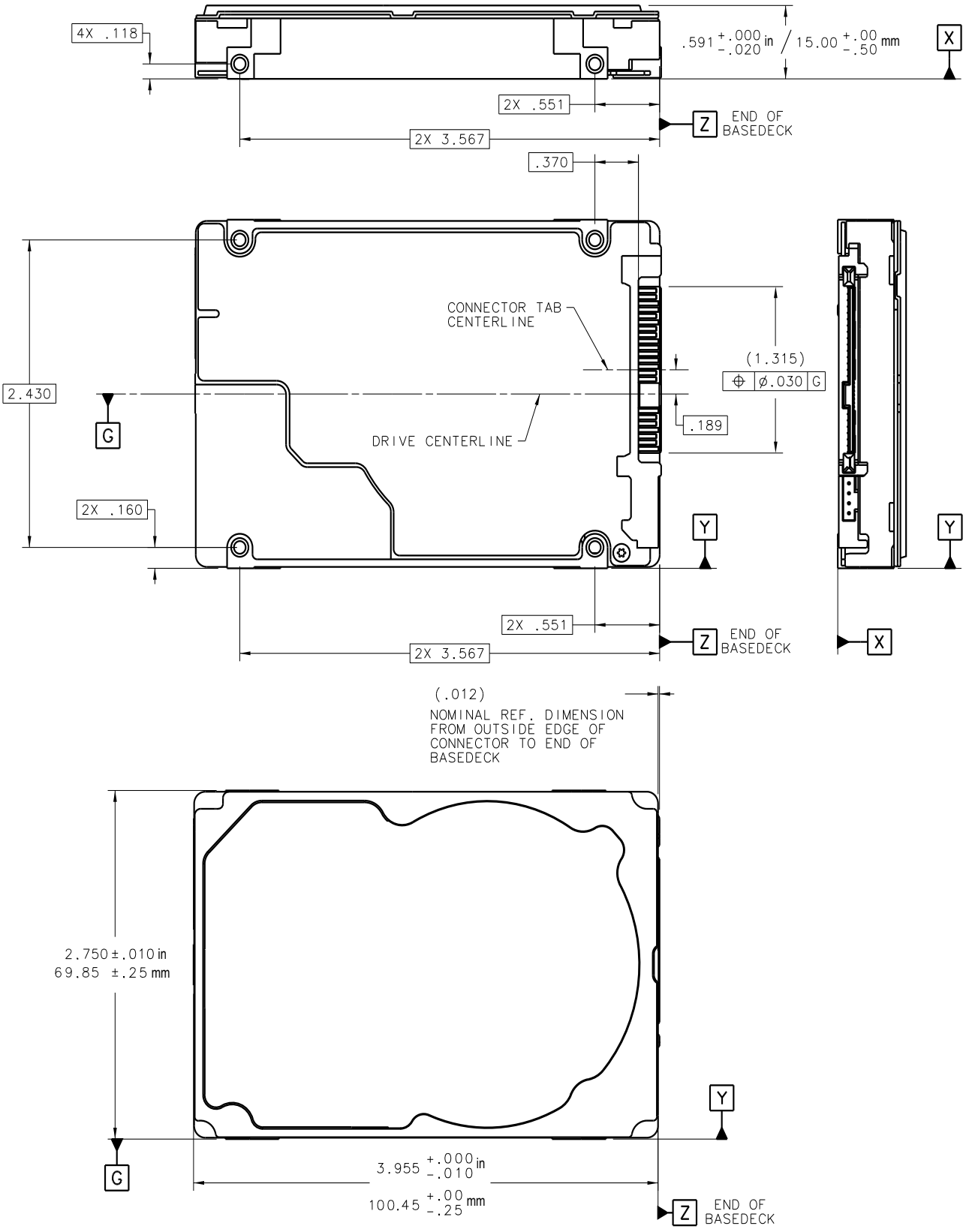


Figure 6. Mounting dimensions—top, side and end view

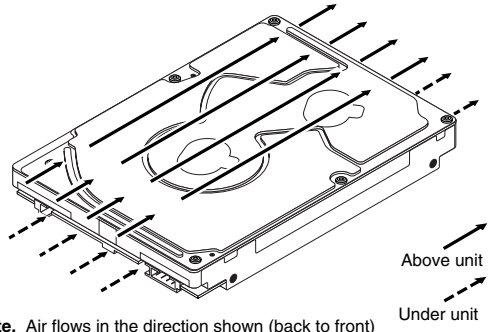
4.5 Cooling

Cabinet cooling must be designed by the customer so that the ambient temperature immediately surrounding the drive will not exceed temperature conditions specified in Section 3.9.1, "Temperature."

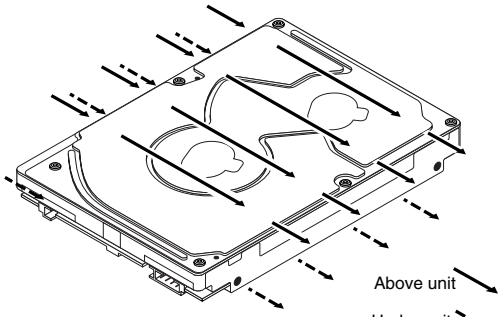
The rack, cabinet, or drawer environment for the drive must provide heat removal from the electronics and head and disc assembly (HDA). You should confirm that adequate heat removal is provided using the temperature measurement guidelines described in Section 3.9.1.

Forced air flow may be required to keep temperatures at or below the temperatures specified in Section 3.9.1 in which case the drive should be oriented, or air flow directed, so that the least amount of air flow resistance is created while providing air flow to the electronics and HDA. Also, the shortest possible path between the air inlet and exit should be chosen to minimize the travel length of air heated by the drive and other heat sources within the rack, cabinet, or drawer environment.

If forced air is determined to be necessary, possible air-flow patterns are shown in Figure 7, page 28. The air-flow patterns are created by one or more fans, either forcing or drawing air as shown in the illustrations. Conduction, convection, or other forced air-flow patterns are acceptable as long as the temperature measurement guidelines of Section 3.9.1 are met.



Note. Air flows in the direction shown (back to front) or in reverse direction (front to back)



Note. Air flows in the direction shown or in reverse direction (side to side)

Figure 7. Air flow

5.0 About FIPS

The Federal Information Processing Standard (FIPS) Publication 140-2, FIPS PUB 140-2, is a U.S. government computer security standard used to accredit cryptographic modules. It is titled “Security Requirements for Cryptographic Modules”. The initial publication was on May 25, 2001 and was last updated December 3, 2002.

Purpose

The National Institute of Standards and Technology (NIST) issued the FIPS 140 Publication Series to coordinate the requirements and standards for cryptography modules that include both hardware and software components.

Federal Information Processing Standard (FIPS) 140-2 Level 2 Certification requires drives to go through government agencies certifications to add requirements for physical tamper-evidence and role-based authentication.

Level 2 security

Level 2 improves upon the physical security mechanisms of a Level 1 (lowest level of security) cryptographic module by requiring features that show evidence of tampering, including tamper-evident coatings or seals that must be broken to attain physical access to the plaintext cryptographic keys and critical security parameters (CSPs) within the module, or pick-resistant locks on covers or doors to protect against unauthorized physical access.

Figure 8. Example of FIPS tamper evidence labels.

Note. Does not represent actual drive.

6.0 About self-encrypting drives

Self-encrypting drives (SEDs) offer encryption and security services for the protection of stored data, commonly known as “protection of data at rest.” These drives are compliant with the Trusted Computing Group (TCG) Enterprise Storage Specifications as detailed in Section 3.14.2.

The Trusted Computing Group (TCG) is an organization sponsored and operated by companies in the computer, storage and digital communications industry. Seagate’s SED models comply with the standards published by the TCG.

To use the security features in the drive, the host must be capable of constructing and issuing the following two commands:

- Security Protocol Out
- Security Protocol In

These commands are used to convey the TCG protocol to and from the drive in their command payloads.

6.1 Data encryption

Encrypting drives use one inline encryption engine for each port, employing AES-256 data encryption in Cipher Block Chaining (CBC) mode to encrypt all data prior to being written on the media and to decrypt all data as it is read from the media. The encryption engines are always in operation, cannot be disabled, and do not detract in any way from the performance of the drive.

The 32-byte Data Encryption Key (DEK) is a random number which is generated by the drive, never leaves the drive, and is inaccessible to the host system. The DEK is itself encrypted when it is stored on the media and when it is in volatile temporary storage (DRAM) external to the encryption engine. A unique data encryption key is used for each of the drive's possible16 data bands (see Section 6.5).

6.2 Controlled access

The drive has two security partitions (SPs) called the "Admin SP" and the "Locking SP." These act as gatekeepers to the drive security services. Security-related commands will not be accepted unless they also supply the correct credentials to prove the requester is authorized to perform the command.

6.2.1 Admin SP

The Admin SP allows the drive's owner to enable or disable firmware download operations (see Section 6.4). Access to the Admin SP is available using the SID (Secure ID) password or the MSID (Makers Secure ID) password.

6.2.2 Locking SP

The Locking SP controls read/write access to the media and the cryptographic erase feature. Access to the Locking SP is available using the BandMasterX or EraseMaster passwords. Since the drive owner can define up to 16 data bands on the drive, each data band has its own password called BandMasterX where X is the number of the data band (0 through 15).

6.2.3 Default password

When the drive is shipped from the factory, all passwords are set to the value of MSID. This 32-byte random value is printed on the drive label and it can be read by the host electronically over the I/O. After receipt of the drive, it is the responsibility of the owner to use the default MSID password as the authority to change all other passwords to unique owner-specified values.

6.3 Random number generator (RNG)

The drive has a 32-byte hardware RNG that it is uses to derive encryption keys or, if requested to do so, to provide random numbers to the host for system use, including using these numbers as Authentication Keys (passwords) for the drive's Admin and Locking SPs.

6.4 Drive locking

In addition to changing the passwords, as described in Section 6.2.3, the owner should also set the data access controls for the individual bands.

The variable "LockOnReset" should be set to "PowerCycle" to ensure that the data bands will be locked if power is lost. This scenario occurs if the drive is removed from its cabinet. The drive will not honor any data read or write requests until the bands have been unlocked. This prevents the user data from being accessed without the appropriate credentials when the drive has been removed from its cabinet and installed in another system.

When the drive is shipped from the factory, the firmware download port is locked and the drive will reject any attempt to download new firmware. The drive owner must use the SID credential to unlock the firmware download port before firmware updates will be accepted.

6.5 Data bands

When shipped from the factory, the drive is configured with a single data band called Band 0 (also known as the Global Data Band) which comprises LBA 0 through LBA max. The host may allocate Band1 by specifying a start LBA and an LBA range. The real estate for this band is taken from the Global Band. An additional 14 Data Bands may be defined in a similar way (Band2 through Band15) but before these bands can be allocated LBA space, they must first be individually enabled using the EraseMaster password.

Data bands cannot overlap but they can be sequential with one band ending at LBA (x) and the next beginning at LBA (x+1).

Each data band has its own drive-generated encryption key and its own user-supplied password. The host may change the Encryption Key (see Section 6.6) or the password when required. The bands should be aligned to 4K LBA boundaries.

6.6 Cryptographic erase

A significant feature of SEDs is the ability to perform a cryptographic erase. This involves the host telling the drive to change the data encryption key for a particular band. Once changed, the data is no longer recoverable since it was written with one key and will be read using a different key. Since the drive overwrites the old key with the new one, and keeps no history of key changes, the user data can never be recovered. This is tantamount to an instantaneous data erase and is very useful if the drive is to be scrapped or redispositioned.

6.7 Authenticated firmware download

In addition to providing a locking mechanism to prevent unwanted firmware download attempts, the drive also only accepts download files which have been cryptographically signed by the appropriate Seagate Design Center.

Three conditions must be met before the drive will allow the download operation:

1. The download must be an SED file. A standard (base) drive (non-SED) file will be rejected.
2. The download file must be signed and authenticated.
3. As with a non-SED drive, the download file must pass the acceptance criteria for the drive. For example it must be applicable to the correct drive model, and have compatible revision and customer status.

6.8 Power requirements

The standard drive models and the SED drive models have identical hardware, however the security and encryption portion of the drive controller ASIC is enabled and functional in the SED models. This represents a small additional drain on the 5V supply of about 30mA and a commensurate increase of about 150mW in power consumption. There is no additional drain on the 12V supply. See the tables in Section 3.8 for power requirements on the standard (non-SED) drive models.

6.9 Supported commands

The SED models support the following two commands in addition to the commands supported by the standard (non-SED) models as listed in Table 6:

- Security Protocol Out (B5h)
- Security Protocol In (A2h)

6.10 RevertSP

The SED models will support RevertSP feature where it erases all data in all bands on the device and returns the contents of all SPs (Security Providers) on the device to their Original Factory State.

7.0 Serial ATA (SATA) interface

These drives use the industry-standard Serial ATA interface that supports FIS data transfers. It supports ATA programmed input/output (PIO) modes 0–4; multiword DMA modes 0–2, and Ultra DMA modes 0–6.

For detailed information about the Serial ATA interface, refer to the “Serial ATA: High Speed Serialized AT Attachment” specification.

7.1 Hot-Plug compatibility

Constellation.2 Serial ATA drives incorporate connectors which enable you to hot plug these drives in accordance with the Serial ATA II: Extension to Serial ATA 1.0a specification. This specification can be downloaded from www.serialata.org.

Caution:

The drive motor must come to a complete stop **(Ready to spindle stop time indicated in Section 3.7)** prior to changing the plane of operation. This time is required to insure data integrity.

7.2 Serial ATA device plug connector pin definitions

Table 5 summarizes the signals on the Serial ATA interface and power connectors.

Table 5: Serial ATA connector pin definitions

Segment	Pin	Function	Definition
Signal	S1	Ground	2nd mate
	S2	A+	Differential signal pair A from Phy
	S3	A-	
	S4	Ground	2nd mate
	S5	B-	Differential signal pair B from Phy
	S6	B+	
	S7	Ground	2nd mate
Key and spacing separate signal and power segments			
Power	P1	V_{33}	3.3V power
	P2	V_{33}	3.3V power
	P3	V_{33}	3.3V power, pre-charge, 2nd mate
	P4	Ground	1st mate
	P5	Ground	2nd mate
	P6	Ground	2nd mate
	P7	V_5	5V power, pre-charge, 2nd mate
	P8	V_5	5V power
	P9	V_5	5V power
	P10	Ground	2nd mate
	P11	Ground or LED signal	If grounded, drive does not use deferred spin
	P12	Ground	1st mate.
	P13	V_{12}	12V power, pre-charge, 2nd mate
	P14	V_{12}	12V power
	P15	V_{12}	12V power

Notes:

1. All pins are in a single row, with a 1.27 mm (0.050”) pitch.
2. The comments on the mating sequence apply to the case of backplane blindmate connector only. In this case, the mating sequences are:
   - the ground pins P4 and P12.
   - the pre-charge power pins and the other ground pins.
   - the signal pins and the rest of the power pins.
3. There are three power pins for each voltage. One pin from each voltage is used for pre-charge when installed in a blind-mate backplane configuration.
4. All used voltage pins (V_x) must be terminated.

7.3 Supported ATA commands

The following table lists Serial ATA standard commands that the drive supports. For a detailed description of the ATA commands, refer to the Serial ATA: High Speed Serialized AT Attachment specification. See “S.M.A.R.T. commands” on page 42.for details and subcommands used in the S.M.A.R.T. implementation.

Table 6: Supported ATA commands

Command name	Command code (in hex)
Check Power Mode	$E5_H$
Device Configuration Freeze Lock	$B1_H$ / $C1_H$
Device Configuration Identify	$B1_H$ / $C2_H$
Device Configuration Restore	$B1_H$ / $C0_H$
Device Configuration Set	$B1_H$ / $C3_H$
Device Reset	08_H
Download Microcode	92_H
Execute Device Diagnostics	90_H
Flush Cache	$E7_H$
Flush Cache Extended	EA_H
Format Track	50_H
Identify Device	EC_H
Idle	$E3_H$
Idle Immediate	$E1_H$
Initialize Device Parameters	91_H
Read Buffer	$E4_H$
Read DMA	$C8_H$
Read DMA Extended	25_H
Read DMA Without Retries	$C9_H$
Read Log Ext	$2F_H$
Read Multiple	$C4_H$
Read Multiple Extended	29_H
Read Native Max Address	$F8_H$
Read Native Max Address Extended	27_H
Read Sectors	20_H
Read Sectors Extended	24_H
Read Sectors Without Retries	21_H
Read Verify Sectors	40_H
Read Verify Sectors Extended	42_H
Read Verify Sectors Without Retries	41_H
Recalibrate	10_H
Security Disable Password	$F6_H$
Security Erase Prepare	$F3_H$

Command name	Command code (in hex)
Security Erase Unit	$F4_H$
Security Freeze	$F5_H$
Security Set Password	$F1_H$
Security Unlock	$F2_H$
Seek	70_H
Set Features	EF_H
Set Max Address Note: Individual Set Max Address commands are identified by the value placed in the Set Max Features register as defined to the right.	$F9_H$ Address: 00_H Password: 01_H Lock: 02_H Unlock: 03_H Freeze Lock: 04_H
Set Max Address Extended	37_H
Set Multiple Mode	$C6_H$
Sleep	$E6_H$
S.M.A.R.T. Disable Operations	$B0_H$ / $D9_H$
S.M.A.R.T. Enable/Disable Autosave	$B0_H$ / $D2_H$
S.M.A.R.T. Enable Operations	$B0_H$ / $D8_H$
S.M.A.R.T. Execute Offline	$B0_H$ / $D4_H$
S.M.A.R.T. Read Attribute Thresholds	$B0_H$ / $D1_H$
S.M.A.R.T. Read Data	$B0_H$ / $D0_H$
S.M.A.R.T. Read Log Sector	$B0_H$ / $D5_H$
S.M.A.R.T. Return Status	$B0_H$ / DA_H
S.M.A.R.T. Save Attribute Values	$B0_H$ / $D3_H$
S.M.A.R.T. Write Log Sector	$B0_H$ / $D6_H$
Standby	$E2_H$
Standby Immediate	$E0_H$
Write Buffer	$E8_H$
Write DMA	CA_H
Write DMA Extended	35_H
Write DMA FUA Extended	CD_H
Write DMA Without Retries	CB_H
Write Log Extended	$3F_H$
Write Multiple	$C5_H$
Write Multiple Extended	39_H
Write Multiple FUA Extended	CE_H
Write Sectors	30_H
Write Sectors Without Retries	31_H
Write Sectors Extended	34_H

7.3.1 Identify Device command

The Identify Device command (command code EC_H) transfers information about the drive to the host following power up. The data is organized as a single 512-byte block of data, whose contents are shown in Table 6 on page 35. All reserved bits or words should be set to zero. Parameters listed with an “x” are drive-specific or vary with the state of the drive. See Section 3.0 on page 4for default parameter settings.

The following commands contain drive-specific features that may not be included in the Serial ATA specification.

Word	Description	Value
0	Configuration information: • Bit 15: 0 = ATA; 1 = ATAPI • Bit 7: removable media • Bit 6: removable controller • Bit 0: reserved	$0C5A_H$
1	Number of logical cylinders	16,383
2	ATA-reserved	0000_H
3	Number of logical heads	16
4	Retired	0000_H
5	Retired	0000_H
6	Number of logical sectors per logical track: 63	$003F_H$
7–9	Retired	0000_H
10–19	Serial number: (20 ASCII characters, 0000_H = none)	ASCII
20	Retired	0000_H
21	Retired	0400_H
22	Obsolete	0000_H
23–26	Firmware revision (8 ASCII character string, padded with blanks to end of string)	x.xx
27–46	Drive model number: (40 ASCII characters, padded with blanks to end of string)	
47	(Bits 7–0) Maximum sectors per interrupt on Read multiple and Write multiple (16)	8010_H
48	Reserved	0000_H
49	Standard Standby timer, IORDY supported and may be disabled	$2F00_H$
50	ATA-reserved	0000_H
51	PIO data-transfer cycle timing mode	0200_H
52	Retired	0200_H
53	Words 54–58, 64–70 and 88 are valid	0007_H
54	Number of current logical cylinders	$xxxx_H$
55	Number of current logical heads	$xxxx_H$
56	Number of current logical sectors per logical track	$xxxx_H$
57–58	Current capacity in sectors	$xxxx_H$
59	Number of sectors transferred during a Read Multiple or Write Multiple command	$xxxx_H$

Word	Description	Value
60–61	Total number of user-addressable LBA sectors available (see Section 3.2 for related information) *Note: The maximum value allowed in this field is: 0FFFFFFFh (268,435,455 sectors, 137 Gbytes). Drives with capacities over 137 Gbytes will have 0FFFFFFFh in this field and the actual number of user-addressable LBAs specified in words 100-103. This is required for drives that support the 48-bit addressing feature.	0FFFFFFFh*
62	Retired	0000_H
63	Multiword DMA active and modes supported (see note following this table)	$xx07_H$
64	Advanced PIO modes supported (modes 3 and 4 supported)	0003_H
65	Minimum multiword DMA transfer cycle time per word (120 nsec)	0078_H
66	Recommended multiword DMA transfer cycle time per word (120 nsec)	0078_H
67	Minimum PIO cycle time without IORDY flow control (240 nsec)	$00F0_H$
68	Minimum PIO cycle time with IORDY flow control (120 nsec)	0078_H
69–74	ATA-reserved	0000_H
75	Queue depth	0000_H
76	Serial ATA capabilities	$xxxx_H$
77	Reserved for future Serial ATA definition	$xxxx_H$
78	Serial ATA features supported	$xxxx_H$
79	Serial ATA features enabled	$xxxx_H$
80	Major version number	$003E_H$
81	Minor version number	0000_H
82	Command sets supported	$364B_H$
83	Command sets supported	$7C03_H$
84	Command sets support extension (see note following this table)	4003_H See Word 108-111 note. (4003H = 0100000000000011 binary)
85	Command sets enabled	$30xx_H$
86	Command sets enabled	0001_H
87	Command sets enable extension	4000_H
88	Ultra DMA support and current mode (see note following this table)	$xx3F_H$
89	Security erase time	0000_H
90	Enhanced security erase time	0000_H
92	Master password revision code	$FFFE_H$
93	Hardware reset value	$xxxx_H$
95–99	ATA-reserved	0000_H
100–103	Total number of user-addressable LBA sectors available (see Section 3.2 for related information). These words are required for drives that support the 48-bit addressing feature. Maximum value: 0000FFFFFFFFFFFFh.	1000GB models = 1,953,525,168 500GB models = 976,773,168 250GB models = 488,397,168
104–107	ATA-reserved	0000_H

Word	Description	Value
108–111	The mandatory value of the world wide name (WWN) for the drive. NOTE: This field is valid if word 84, bit 8 is set to 1 indicating 64-bit WWN support.	Each drive will have a unique value.
112–127	ATA-reserved	0000_H
128	Security status	0001_H
129–159	Seagate-reserved	$xxxx_H$
160–254	ATA-reserved	0000_H
255	Integrity word	$xxA5_H$

Note. See the bit descriptions below for words 63, 84, and 88 of the Identify Drive data.

Description (if bit is set to 1)		
	Bit	**Word 63**
	0	Multiword DMA mode 0 is supported.
	1	Multiword DMA mode 1 is supported.
	2	Multiword DMA mode 2 is supported.
	8	Multiword DMA mode 0 is currently active.
	9	Multiword DMA mode 1 is currently active.
	10	Multiword DMA mode 2 is currently active.
	Bit	**Word 84**
	0	SMART error loggin is supported.
	1	SMART self-test is supported.
	2	Media serial number is supported.
	3	Media Card Pass Through Command feature set is supported.
	4	Streaming feature set is supported.
	5	GPL feature set is supported.
	6	WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands are supported.
	7	WRITE DMA QUEUED FUA EXT command is supported.
	8	64-bit World Wide Name is supported.
	9-10	Obsolete.
	11-12	Reserved for TLC.
	13	IDLE IMMEDIATE command with IUNLOAD faeture is supported.
	14	Shall be set to 1.
	15	Shall be cleared to 0.

	Bit	Word 88
	0	Ultra DMA mode 0 is supported.
	1	Ultra DMA mode 1 is supported.
	2	Ultra DMA mode 2 is supported.
	3	Ultra DMA mode 3 is supported.
	4	Ultra DMA mode 4 is supported.
	5	Ultra DMA mode 5 is supported.
	6	Ultra DMA mode 6 is supported.
	8	Ultra DMA mode 0 is currently active.
	9	Ultra DMA mode 1 is currently active.
	10	Ultra DMA mode 2 is currently active.
	11	Ultra DMA mode 3 is currently active.
	12	Ultra DMA mode 4 is currently active.
	13	Ultra DMA mode 5 is currently active.
	14	Ultra DMA mode 6 is currently active.

7.3.2 Set Features command

This command controls the implementation of various features that the drive supports. When the drive receives this command, it sets BSY, checks the contents of the Features register, clears BSY and generates an interrupt. If the value in the register does not represent a feature that the drive supports, the command is aborted. Power-on default has the read look-ahead and write caching features enabled. The acceptable values for the Features register are defined as follows:

Table 7: Set Features command values

- 02_H Enable write cache *(default).*
- 03_H Set transfer mode (based on value in Sector Count register).
  Sector Count register values:
  - 00_H Set PIO mode to default (PIO mode 2).
  - 01_H Set PIO mode to default and disable IORDY (PIO mode 2).
  - 08_H PIO mode 0
  - 09_H PIO mode 1
  - $0A_H$ PIO mode 2
  - $0B_H$ PIO mode 3
  - $0C_H$ PIO mode 4 *(default)*
  - 20_H Multiword DMA mode 0
  - 21_H Multiword DMA mode 1
  - 22_H Multiword DMA mode 2
  - 40_H Ultra DMA mode 0
  - 41_H Ultra DMA mode 1
  - 42_H Ultra DMA mode 2
  - 43_H Ultra DMA mode 3
  - 44_H Ultra DMA mode 4
  - 45_H Ultra DMA mode 5
  - 46_H Ultra DMA mode 6
- 10_H Enable use of SATA features
- 55_H Disable read look-ahead (read cache) feature.
- 82_H Disable write cache
- 90_H Disable use of SATA features
- AA_H Enable read look-ahead (read cache) feature *(default).*
- $F1_H$ Report full capacity available

Note. At power-on, or after a hardware or software reset, the default values of the features are as indicated above.

7.3.3 S.M.A.R.T. commands

S.M.A.R.T. provides near-term failure prediction for disc drives. When S.M.A.R.T. is enabled, the drive monitors predetermined drive attributes that are susceptible to degradation over time. If self-monitoring determines that a failure is likely, S.M.A.R.T. makes a status report available to the host. Not all failures are predictable. S.M.A.R.T. predictability is limited to the attributes the drive can monitor. For more information on S.M.A.R.T. commands and implementation, see the *Draft ATA-5 Standard.*

SeaTools diagnostic software activates a built-in drive self-test (DST S.M.A.R.T. command for $D4_H$) that eliminates unnecessary drive returns. The diagnostic software ships with all new drives and is also available at: http://seatools.seagate.com.

This drive is shipped with S.M.A.R.T. features disabled. You must have a recent BIOS or software package that supports S.M.A.R.T. to enable this feature. The table below shows the S.M.A.R.T. command codes that the drive uses.

Table 8: S.M.A.R.T. commands

Code in features register	S.M.A.R.T. command
$D0_H$	S.M.A.R.T. Read Data
$D2_H$	S.M.A.R.T. Enable/Disable Attribute Autosave
$D3_H$	S.M.A.R.T. Save Attribute Values
$D4_H$	S.M.A.R.T. Execute Off-line Immediate (runs DST)
$D5_H$	S.M.A.R.T. Read Log Sector
$D6_H$	S.M.A.R.T. Write Log Sector
$D8_H$	S.M.A.R.T. Enable Operations
$D9_H$	S.M.A.R.T. Disable Operations
DA_H	S.M.A.R.T. Return Status

Note. If an appropriate code is not written to the Features Register, the command is aborted and 0*x*04 (abort) is written to the Error register.

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920 Disc Drive, Scotts Valley, California 95066-4544, USA
Publication Number: 100545983, Rev. C